NASA and US Contributions to Herschel

Herschel Space Observatory

- Herschel is an ESA Observatory-class submillimeter/far-IR mission
- Complete coverage from 60 to 670 microns
- Photometry and Spectral Capability
- Launch in 2007
- Lifetime in $L_2 > 3$ years
- 3.5 m telescope passively cooled to 70-90K

NASA Funded US Contributions

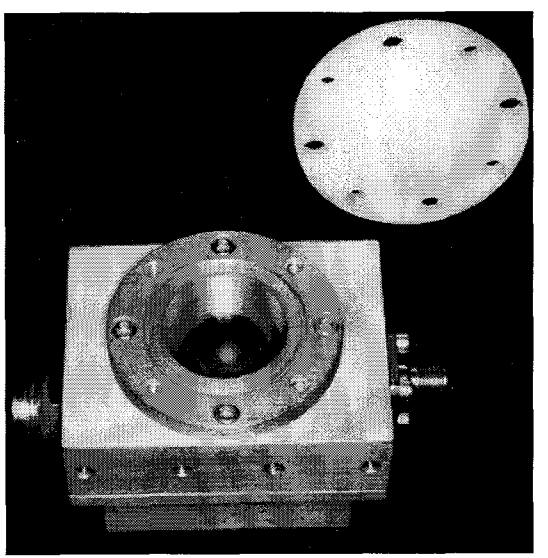
- Two instruments
  - HIFI (Partial NASA funding)
    - Spectroscopy
    - 0.48 -1.91 THz, $\lambda/\Delta\lambda > 10^6$
  - SPIRE (Partial NASA funding)
    - Imaging photometry
    - 200μm - 670μm, $\lambda/\Delta\lambda \sim 10^3$
    - Broadband Spectroscopy
- US Herschel Science Support Center
- Technology Studies for a Lightweight Telescope

Expected Science Return to US Community

- Key Projects (Peer Reviewed)
  - US Representation on Selection Committees
- Open Time (Peer Reviewed)
  - Openly competed without any fixed allocation
  - US Representation on Time Allocation Committees (TACs)

Heterodyne Instrument for the Far Infrared (HIFI)

- PI: Thijs de Grauuw, SRON, Groningen, The Netherlands
- Co-PI: Tom Phillips (Caltech)
- Five SIS Receivers with continuous coverage 480 - 1250 GHz
  - Large bandwidth of 4 GHz, and very high spectral resolution, $\lambda/\Delta\lambda > 10^6$
- HEB Receiver with coverage in the range 1.41 - 1.91 THz
- NASA Funded contributions:
  - Band 5 - SIS Mixer (Leads Zmuidzinas & Karpov)
  - Band 6 - HEB Mixer (McGrath, JPL)
  - LO Chains for Bands 5 and 6 (Mehdi, Pearson)
  - LO Components for Bands 1 - 4
  - Power Amplifiers (Gaier)



US Contributions to HIFI

Band 5 SIS Mixers

RF Freq: 1.12 - 1.25 THz

IF Freq: 4 - 8 GHz

Sensor: Superconducting Insulating Superconducting (SIS) mixer

Material:NbTiN

LO Power: ≈ 10 μW

Sensitivity: < 1500K

Band 6 HEB Mixers

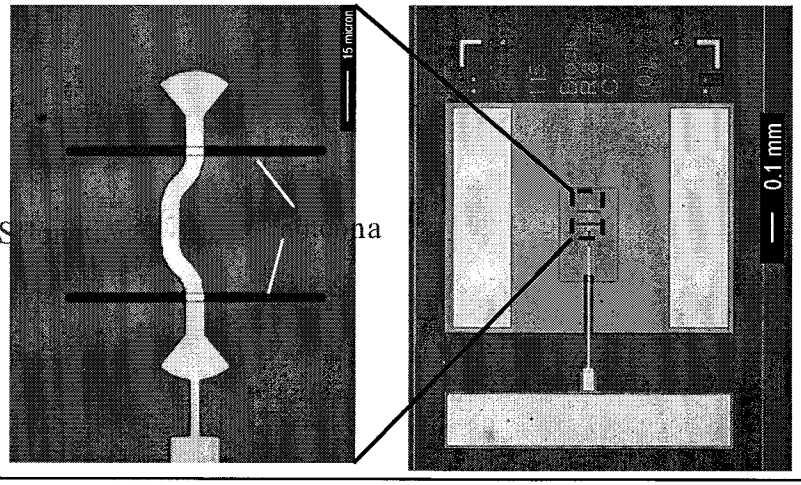
RF Freq: 1.4 - 1.9 THz

IF Freq: 4 - 8 GHz

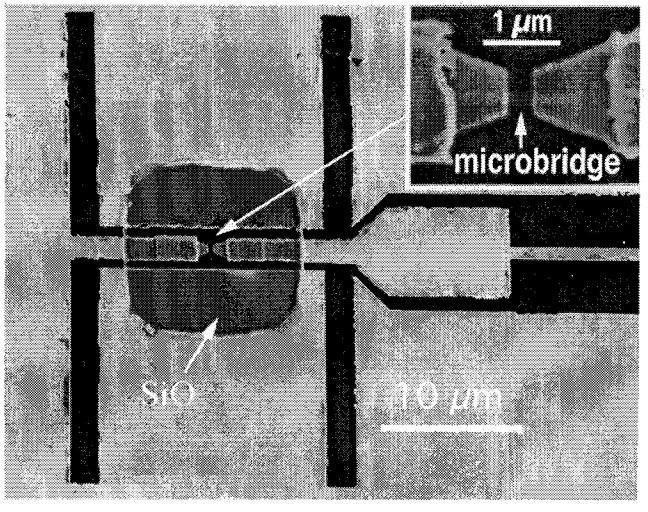
Sensor: Diffusion-cooled superconducting Hot Electron Bolometer (HEB) mixer

Material: Nb

LO Power: ≈ 100 nW



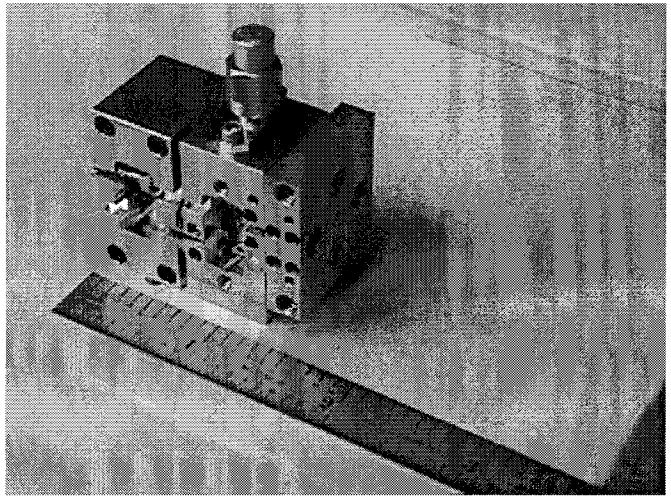
SIS [illegible] na



US Contributions to HIFI - Continued

Multiplier Chains

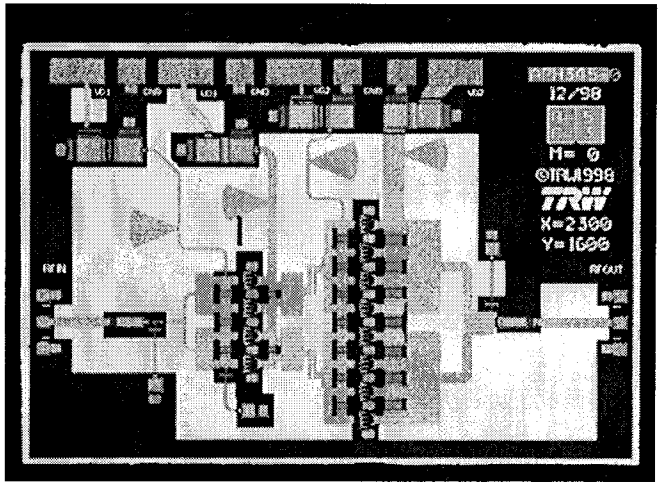
Multiplier chains are needed to supply the RF power at the high frequencies being used on HIFI. The complete chain consists of a series of doublers and triplers. Shown below is the complete assembly for one chain.



Power Amplifiers

Power amplifiers will supply the RF power for the passive multipliers in the HIFI Local oscillator. Amplifiers in four frequency ranges between 71 and 106 GHz will be constructed using MMIC circuit designs fabricated from TRW's 0.1 mm GaAs technology. The program is a partnership between JPL and TRW.

High Power Amp for 3rd Stage



Spectral and Photometric Imaging REceiver - SPIRE

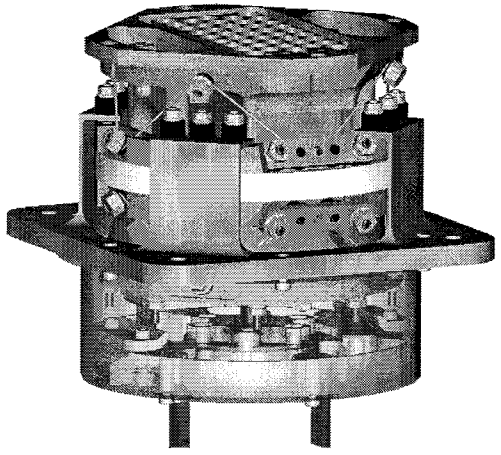
- PI - Matt Griffin (Queen Mary and Westfield College, London)
- Bolometer Arrays built at JPL (JPL Lead - Jamie Bock)
- Broad Band Photometry (200 - 670 μm)
  - 250, 350 and 500 μm bands,
  - $\lambda/\Delta\lambda \sim 3$
- Up to ~ 450 pixels
  - Diffraction limited resolution (18" at 250 μm)
- FTS Spectroscopy:
  - 200 - 670 μm
  - $\lambda/\Delta\lambda \sim 1000$ at 250 μm

- NASA Funded US Critical Contributions:
  - Bolometer detectors
    - Arrays of MEMS fabricated spider web supported NTD germanium absorbers.
    - Cryogenic Readout Electronics
    - Provide extremely low noise amplification of detector signals co-located with bolometer detectors in cryostat
  - Electrical harnesses
    - Interconnecting detectors and cold electronics carrying 1,000's of conductors.
  - Detector test program including five cryogenic testing facilities

US Contributions to SPIRE

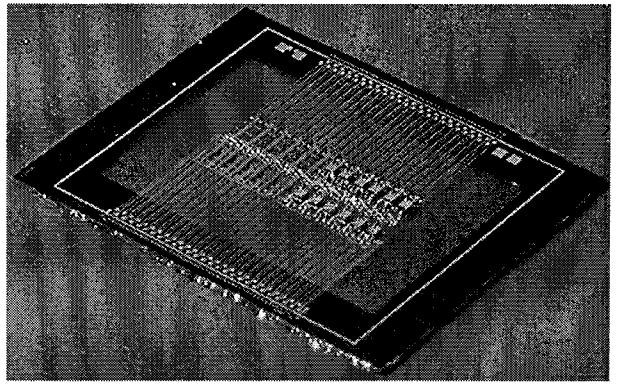
- Bolometer Detector Assemblies
  - 3 Photometer band units
  - 2 Spectrometer band units
  - Units are 2-stage temperature passively controlled
    - Kevlar supported <300 mK structure with bolometers
    - Interface structure at 2 K
  - Feedhorn arrays constructed of plated copper over mandrels

Bolometer Detector Assembly



Lithographed JFET membrane

- Cryogenic Readout Electronics
  - JFETs provide power amplification for bolometer signals



US Contributions to SPIRE -continued

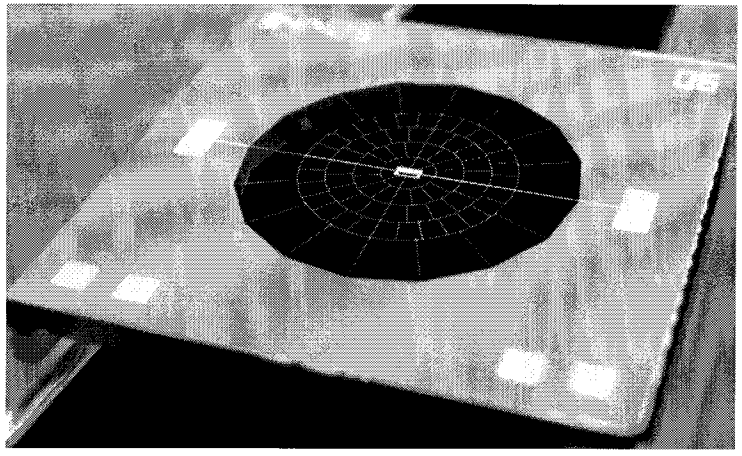
Spider-web architecture provides
- low absorber heat capacity
- minimal suspended mass
- low-cosmic ray cross-section
- low thermal conductivity = high sensitivity

Sensitivities and heat capacities achieved to date:
- NEP = 1.5 x 10^{-17} W/$\sqrt{}$Hz, C = 1pJ/K at 300 mK
- NEP = 1.5 x 10^{-18} W/ $\sqrt{}$ Hz, C = 0.4 pJ/K at 100mK

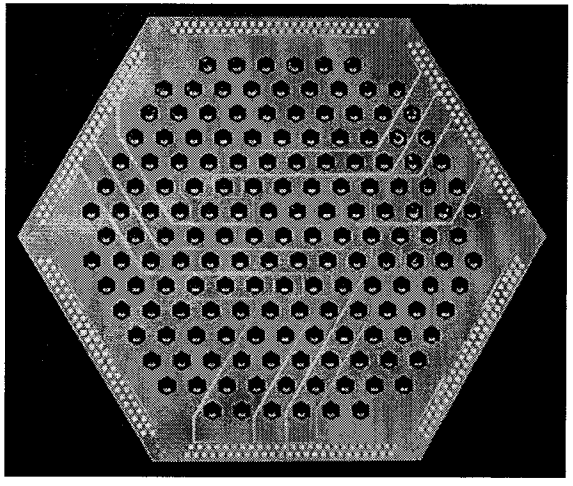
Baseline detector for ESA/NASA Planck HFI

Planned or operating in numerous sub-orbital experiments:

BOOMERANG	Caltech	Antarctic balloon CMB instrument
SuZIE	Stanford	S-Z instrument for the CSO
MAXIMA	UC Berkeley	North America balloon CMB instrument
BOLOCAM	UMass	Bolometer camera for the CSO
ACBAR	UC Berkeley	Antarctic S-Z survey instrument
MAT	UPenn	CMB experiment for Chile
POLATRON	Caltech	CMB polarimeter for OVRO
Archeops	CNRS, France	CMB balloon experiment
PRONAOS	IAS, France	Submillimeter balloon experiment
BLAST	U. Penn	Submillimeter balloon experiment



Close up of one spider web pixel



Representative Spider Webs in an Array

US Herschel Science Center

- Established at the Infrared Processing and Analysis Center (IPAC) under support from NASA/JPL
- Begins operations this year, and will continue throughout the lifetime of the Herschel mission.
- Provide the US astronomical community with science and observational support throughout all phases of the Herschel mission.
- Work to ensure that the necessary resources and tools are available to the US community to take full advantage of the observatory's scientific capabilities.
- Advocate for the needs of US-based Herschel observers both here and abroad.
- Provide community and observer support during proposal preparation, observation planning and data analysis (including documentation, hands-on expertise, and custom software)
- Develop software tools for observation planning by observers
- Develop software tools for data analysis by observers
- Provide archiving and distribution of Herschel data
- Work with the ESA-Herschel Science Center, the HIFI, PACS and SPIRE Instrument Teams, and U.S. observers (Open-time, Legacy, and Guaranteed-Time) to help optimize their Herschel-based science.

For further information, visit the NHSC web site at IPAC, http://www.ipac.caltech.edu